§12. Comparison between Retrieved and Measured Phase Profiles of Quasi-Optical Beams

Idei, H. (Kyushu Univ.), Shimozuma, T.,
Shapiro, M.A. (MIT), Notake, T. (Nagoya Univ.),
Kubo, S., Temkin, R.J. (MIT), Ohkubo, K.

A fine alignment of the propagating beam can be realized if direct phase measurements of the beam are available. The phase profiles may indicate how strongly the beam is expanded/focused, and it is tilted. The Gaussian-like beam was analyzed by the moment method, related to the beam axes and sizes, using the intensity and phase patterns measured in the low power test [1]. The evolution of the beam center along the propagation was derived from the intensity measurements by the first order moment analysis. The beam alignment within the tolerable limit of 0.2 degree for the beam coupling into corrugated waveguides was checked and realized using the moment method at the test stand. In order to study the coupling, the Gaussian-like beam was injected to a waveguide with the tilt angles. The intensity pattern of the output beam from the waveguide after the coupling had offsets on the beam centers and side-lobes due to the tilted injection. The phase pattern was distorted from a paraboloid. The desired Gaussian content in the output beam was analyzed, based on the measured intensity and phase patterns. In order to compare between the retrieved and measured phase profiles, the output beam after coupling with the tilt angles is used here. The distorted intensity patterns with the side-lobes of the beam are measured along the propagation. The phase patterns are retrieved from the intensity measurements. The retrieved phase profiles are compared to the measured ones. Figure 1 shows a schematic of the experiment on the tilted injection.

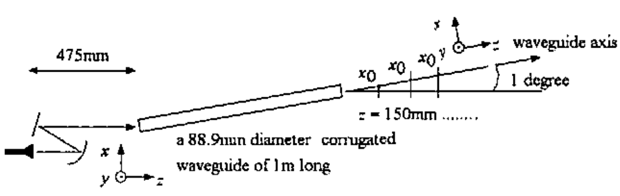

Figure 1: Schematic of low power test measurements.

Figure 2 shows the intensity and phase patterns of the output beam from the waveguide at the propagating position of z= 15cm. Since the input beam is tilted with respect to the waveguide axis, mixture modes of the waveguide including a Gaussian-like HE11 mode are excited. The intensity pattern of the beam output beam has the offset on the beam center and is deformed with a side-lobe. The phase front of the beam is not parabolic and contains some aberrations. The beam is distorted mainly in the x direction by the tilt.

(a) (b)

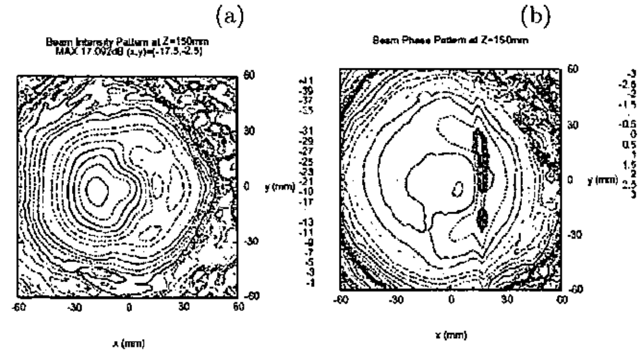

Figure 2: (a) Intensity and (b) Phase patterns of the output beam at z =15cm.

The phase profiles are retrieved from the measured intensity patterns along the propagation with the MIT code[2]. The three intensity patterns are used for the phase retrieval code, and then, the intensity patterns measured and calculated with the code are compared at the reference plane. The two data sets, at z=15/25/35cm and at z=20/30/40cm, are available for the phase retrieval here. The retrieved phase profiles both in the x and y directions are precisely compared to the measured phase profiles with cuts at beam center lines. The retrieved and measured phase data are interpolated in the intensity dynamic range of about 30dB at this comparison. Figures 3 show the retrieved and measured phase profiles at the propagating positions of z=15cm. The retrieved phase profiles derived from the two data sets of the intensity patterns are plotted in the figures. The figure indicate excellent agreement between the retrieved and measured phase profiles. The phase retrieved from the two intensity data sets are in good agreement.

(a) (b)

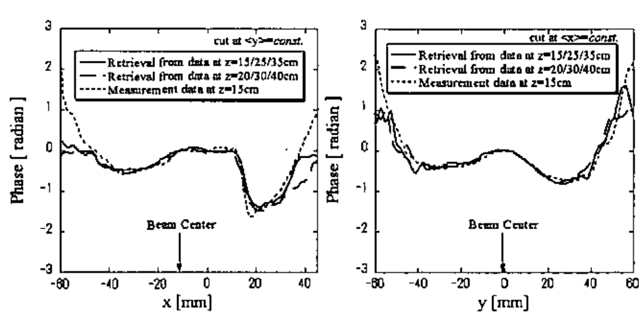

Figure 3: (a) and (b): Retrieved and measured phase profiles in x and y directions at z=15cm.

Reference
1) Idei, H., *et al.* Proceedings of the 27th IRMMW Conf. (2002) T5.3
2)Shapiro, M. A., *et al.* Fusion Eng. Design 53 (2001) 537-544.